ASTROBIOLOGY, HABITABILITY AND THE MOON

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Abstract: Lunar exploration provides a high potential to foster the objectives of astrobiology . The Moon played a key role in early Earth evolution, and is unique platform to perform life sciences, astrobiology [1-16]. We review how to acquire knowledge to make the Moon habitable (using advanced and sustained technological support), and expand life beyond Earth planet of origin.

The renewed lunar exploration: Results from recent lunar missions have changed our view of the Moon. ESA SMART1 was launched in 2003 and has orbited the Moon until impact in Sept. 2006.

Lunar orbiters launched in 2007 (the Chinese Chang'E1, Japanese SELENE Kaguya) are delivering new results. In the second half of 2008, we expect the launch of the Indian ISRO Chandrayaan-1 orbiter as well as US Lunar Reconnaissance Orbiter and LCROSS impactor.

From 2010 a series of soft landing missions to the Moon could emplace a global robotic presence with precursor life science experiments.

Moon and astrobiology: The results of these missions will continue to answer open questions about the origin of the Earth–Moon system, the early evolution of life, the planetary environment and habitability.

Lunar geo-science studies help to understand the origin and evolution of our unique Earth-Moon system and other rocky planets.

Lunar or cis-lunar telescopes on the Moon can detect and characterize if life exists elsewhere in the universe.

We can search for samples of the early Earth on the Moon.

We can use in-situ resources necessary to support future life and human presence (e.g. water, oxygen).

Moon as a test bed for solar system exploration:
- Moon-Mars science synergies
- Instrument technologies
- Robotic outposts
- Tele-presence, Virtual reality
- Deployment of large infrastructures
- Earth-Moon L1 libration point for transfer
- Coordination humans and robots
- Medical aspects
- Biospheres on the Moon
- Human expansion in solar system

Astrobiology and life sciences on the Moon: The Moon will be used for life sciences, astrobiology laboratories, human bases and biospheres that will play a key role in the future of life beyond Earth. This can be started already in robotic missions, with progressive studies:
- Analysis of organics from extraterrestrial samples
- Bacteria and extremes of life
- Survival, replication, mutation and evolution
- Extraterrestrial botanics: Growing plants on the Moon
- Animals: physiology and ethology on another planet
- Closed Ecological Life Support Systems,
- Greenhouses and Food production
- Living off the land

Expanding Life & Humans on the Moon: A Lunar Exploration Roadmap can be given in an broad historical perspective:

1965	First organisms (Luna, Ranger)
1969	First humans (Apollo)
	Robotic precursors in orbit
1994	Clementine, Prospector
2003	SMART-1
2007	SELENE Kaguya, Chang'E1
2008	LRO, LCROSS
2010	Orbiters
2011	GRAIL, LADEE
2012	Landers and robotic Outposts
	Virtual telepresence
	International Lunar Network
	Evolving life on the Moon
	Ecosystem experiments
	Plants, animals
	Resource utilization
	Robotic village
	Life support systems
2017	Sample returns
2019	Short crew missions
2020	Humans and Lunar bases
2024	Permanent human base
2030	Expansion
2040	International Lunar Village
2060	Cities on the Moon

Elements for Human Moon/Mars Exploration: New technologies and systems must be developed for future Human Exploration of the Moon and Mars:

• Advanced Launch /access to space
• Orbital Infrastructure
• Transport/ communication
• Habitable Descent / Ascent Vehicle

• Surface Power Generation
• In-Situ Fuel Production
• Robotic outposts and rovers

• Habitation Modules
• Workshop
• Scientific Laboratories
• Greenhouse / Agriculture Module
• Medical Centre

• Pressurized Rover
• Advanced EVA Suit
  • Life Support Systems

Aurora exploration initiative: Having reached maturity in human space-flight with the development and operation of the International Space Station (ISS), the next step for human kind will be to reach out to other planets in the solar system. They will start first as explorers and then spend extended living and working periods on lunar and planetary bases.

Precursor missions with soft and precision landing, drilling and sample return, in-situ resource utilisation will also greatly advance our technology capability. Technology spin-offs are expected in spacecraft and crew systems autonomy, communications, navigation for precision targeting to distant places, data transmission technology for large volumes of data, information technologies, non-conventional power and propulsion systems, reliable and efficient thermal control for extreme temperatures, radiation hardened electronics, “self-repairing” and adaptable software, in-situ resources utilisation, and robotics.

In line with the European long-term strategy to explore the Solar System and the Universe and to prepare for the “next step” in human space exploration, a new Programme – Aurora, has been proposed by ESA. The programme proposal, with an initial period of technology studies outlines a preparatory framework for robotic and then human exploration missions. Its focus is on Mars, the Moon and Near Earth Objects.

It is characterised by a phased scenario with remote sensing first, then automated planetary in-situ reconnaissance, sample return and eventually the transportation and assembly of the necessary infrastructure for human in-situ exploration at the final destination. The scenario will be implemented in full synergy with other planetary missions planned elsewhere.

Its science objectives are the search for life in the Solar System, the search for the origin of the solar system and to extend the sphere of habitability beyond Earth orbit. Apart from its technological challenges, the programme also serves as an exciting and peaceful goal to society.

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